The subject of the present note is rather general but special mentions to the SPIRE instrument has been introduced to help the understanding of specific principles adopted here.

By the way, these specific principles are tightly attached to the adopted instrument configuration and environmental constraints for the flight. Changes on one of them or both and the « specific principles » could be drastically affected. That's the EMC ambiguity.

1.1 GENERIC APPROACH

We first have to take into account that all devices generating, converting or consuming power are noisy sources and :

All injected current must inevitably return to its own source.
All induced current must inevitably circulates into conductive tracks and structures, in one or several loops.
Induced voltages always exist loops being closed or not.
In higher frequency, injected or induced currents circulate everywhere. Loops and network grounding concepts are superfluous. Common mode impedance (inductance) is the main trouble.

In basic system instrumentation where victims and noisy sources are well identified it is mandatory to create barriers between the both worlds. In a more complex situation or when both worlds share the same location, a hierarchy shall be identified. It shall be noted that the level of susceptibility of victims and parasitic emission of noisy sources are not accuratly known excepted when the system has reached its final and definitive configuration in its proper environment.

Most of the time reducing parasitic emission at source level is very hard to achieve and useless if not performed on all noisy sources with an appropriate accuracy. The latter being out of control this work would lead to wasted time and money (space qualification of exotic devices) if not kept at reasonnable level and then limited results. Only the barrier concept can be kept under control with reasonnable chances of success.

It shall be also noted that none barrier is perfect. In addition, most of the EMC remedies are in contrast one with each other and shall be used with distinction. Excessive use of EMC cures have opposite effects, generates huge interactivities into the system leading to uncontrolled situation.

EMC strategie shall be kept clear, simple and stupid. Impacts on the design shall be taken into account from the beginning. Details shall be consolidated along the project. Due to contrasts each cure affects the next one. This is why each cure shall have limited number of impacts and shall respond, as much as possible, to a precise requirement in a hierarchical order.

Class of devices in order of importance :

Victims :

- Sensors or transducers
- Low level amplifiers
- ADC
- …

Noisy sources :

- Power generator
- Power converter and chopper
- Digital devices
- Power amplifiers
- Power loads
- …

Special class of noisy sources are related to the environmental Electromagnetic fields and Electrostatic discharges.

In the following text « mandatory » is very often used. It shall be interpreted as the most effective technic when applicable. To go against would lead to increase the level of incertities in a world where there are already many of them.

1.2 NOISY SOURCE CURES IN ORDER OF IMPORTANCE

It shall be first noted that due to thermal constraints the electrical environment of the main victim (FPU sensors) is highly resistive (also inductive). A common grounding reference cannot be identified. Any injected current towards the FPU is highly susceptible to generate common mode voltages of several orders of magnitude higher than the useful signal.

1.2.1 Common mode Injected currents

Objective : to stop raising up currents or voltages towards the FPU.

Directly in proportion with involved powers, they cannot be avoided or even reduced. They come from any connexion to external or internal noisy sources (wires, shieldings, ground-power planes..). They must return promptly to their own sources (e.g. other units, generators, converters, amplifiers, digital devices…). Return paths shall be short and via the chassis footprints for the peripheral noisy sources when a good conductive blanket is available. Common mode impedances shall be kept very low especially where these impedances are shared with the victim (contact between DRCU units and the conductive plateform). Surface contacts are then mandatory.

In a hierarchical order, low level amplifiers shall be referenced to the chassis at the FPU connector side where the common mode voltage of the FPU-DRCU harnesses is referenced. Chassis is the only conductor presenting the lowest impedance at all frequency. In order to limit internal loops, inner grounding planes supporting low level amplifiers and ADC shall be connected to the chassis near the connector location.

Analog and digital circuitries are inevitably closely linked via the ADC on the same board. To reduce common mode impedance effects a large ground plane is mandatory. Zonal analog and digital circuitry is mandatory in order to reduce mixed currents into the ground plane. Digital entrance circuitry shall be referenced to chassis in a short way. Peripheral surface contacts between chassis and ground planes are then also mandatory.

On the SVM plateform, where all the power devices are concentrated, electrical loops between units are the rule for injected current feedback reasons. Internal electrical devices in units other than DRCU could be left floating but that means all injected currents in the system will flow throught the DRCU before to get back to their sources increasing common mode impedance problem at DRCU level.
Besides, there are numerous parastic capacitance and resistance everywhere in a so complex and so concentrated warm electronics. To be efficient filtering on power devices needs also to be referenced to chassis in order to meet common mode emission ESA requirements. Therefore the floating concept is not well defined when over few kHz and could bring additionnal troubles in the transition regions. Floating concept need to be used with distinction and where under control. Good common mode rejection technics is then obviously mandatory at units inputs.

1.2.2 Common mode Induced currents

Objective : to stop raising up currents or voltages towards the FPU.

Induced currents are generated by electrostatique discharges and electromagnetique fields coming from the environment or from inner or outer power devices. The major part come from the SVM plateform where all power devices are concentrated. An other part come from the loop antennas made up by all harnesses between FPU and SVM.

Harness shieldings are a part of the overall enclosure consisting in a single Faraday cage surrounding all the instrumentation from the FPU and including each unit box on the SVM plateform. It is the main barrier to induced current effects. This Faraday cage is not perfect especially on harness sides.

First of all harness shieldings, must be electricaly in contact all along with the metallic structure of the satellite in order to return promptly to the source the huge current induced by electrostatique discharges and then to reduce high voltage propagation to the victims. This is also valid for unit boxes. Specific ESD protections can be used when isolation is required at some places.

In NONE CIRCUMSTANCES this Faraday cage can be broken. Harness shielding shall be attached on 360° at both ends on backshells. Flexible harness shielding shall have a resistance as low as possible in order to be efficient at lower frequency. Optical aperture of flexible shielding shall be kept as low as possible in order to improve the shielding efficiency. Electrical continuity via wire bonding even on few centimetres is simply BANNED.

Then loops exist anyway. If it is not the case at some places then especially long transmission lines are perfect monopole antennas. Induced currents on shielding are unavoidable. Therefore reducing loop areas in the 3 dimensions is mandatory.
To keep tight contact between harnesses and conductive structure and blanket is already a good approach. To tight harnesses all together along the instrument chain and especially between the SVM and the FPU is mandatory.

Residual effects are strictly equivalent to injected currents effects and therefore the same cures are reported here.

1.3 FPU SIGNAL TRANSMISSION

Objective. To transport the correct signal to the right location

Shielding starts to be efficient above few kHz (c.f. above conditions). Below, inner wires and traks are susceptible to common mode emission and especially to magnetic fields. Common mode voltages due to residual injected current still exist at all frequencies. Transfert to the differential mode shall then be strictly limited and kept under control.

When the frequency bandwidth of main victim is below few kHz, at the end of a transmission line, and when a good conductive structure is not available to reduce common mode impedance with the rest of the instrumentation chain, the only effective solution is therefore to keep the victim floating (very common solution for thermocouple in noisy industry like Aluminum Foundry for instance).

Electrical isolation shall be kept under control. Symmetrical and balanced impedance lines shall compensate for isolation defects especially at medium frequency. High common mode rejection shall be used at amplifier inputs. Harness shielding efficiency and HF filtering attenuation shall be optimised in order to avoid detection effects on non-linear devices and to accommodate the amplifier inputs.

Symmetrical and balanced impedance lines is one of the rare EMC technic which always help in a cumulative way. However its validity domain is limited. In usual situation we cannot expect more than 20 to 30 dB of additional common mode rejection. To get some improvements special care shall be taken on all parts involved in the transmission lines and at all frequencies. If necessary dedicated parts can be introduced into the transmission line in order to get a better control on the dispersed characteristics of the transmission line, especially in the transition regions.

Capacitive feedthroughs have been introduced for this reason. They act on many ways : on the dispersed characterics of the transmission lines, as part of RF filtering attenuator, and especially to reflect the common mode voltage towards the input amplifier before the victim to be affected by its own parasitic capacitor (isolation defect). The latter can also be understood as a barrier for injected currents into the victim for frequencies over the useful bandwidth. To be effective feedthrough capacitance shall be much higher than all parasitic capacitance.

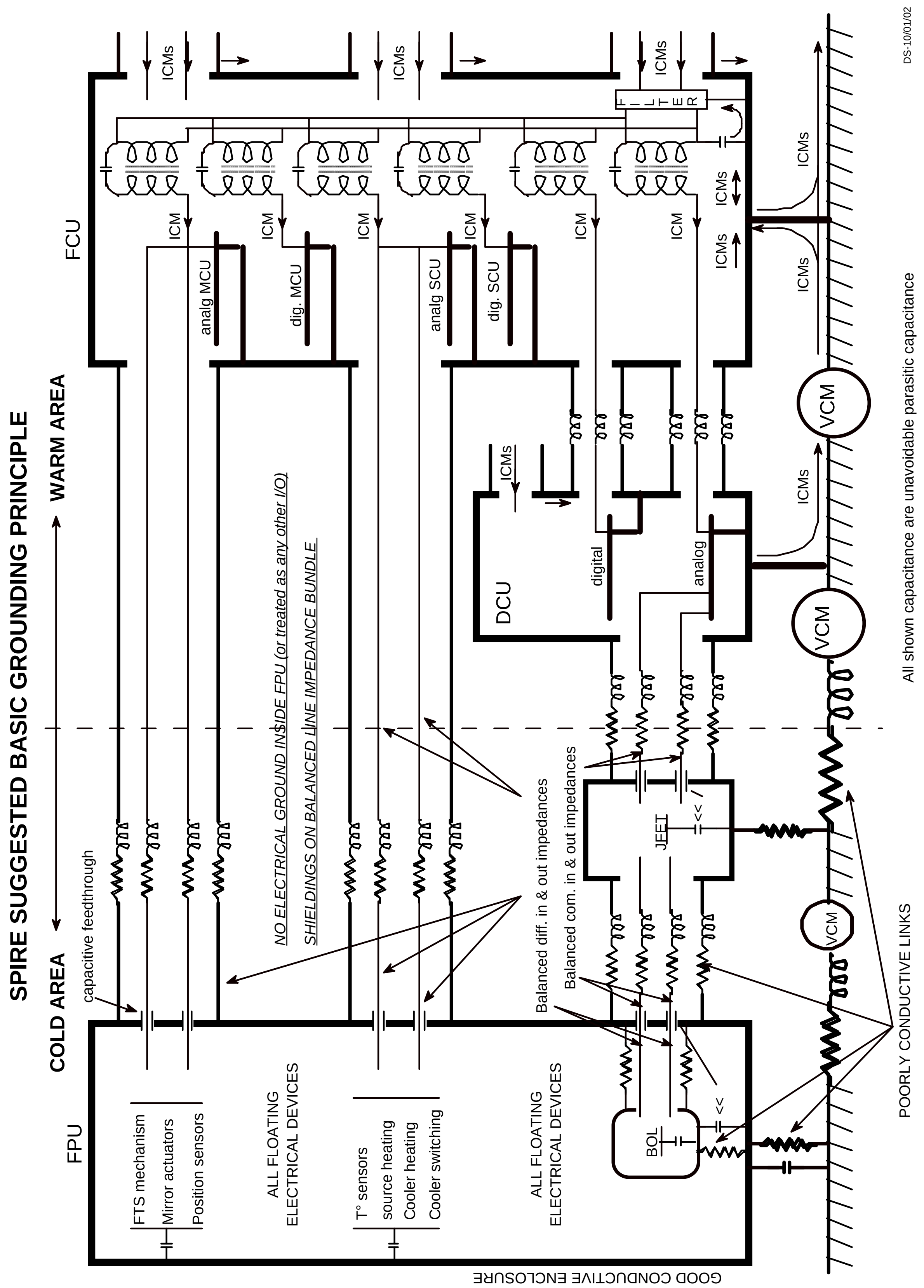
1.4 CROSSTALKS

Crosstalk effects is an important topic but in a second order of magnitude. EMC cures are quite usual and have limited impacts on the overall design and then kept out of the present note.

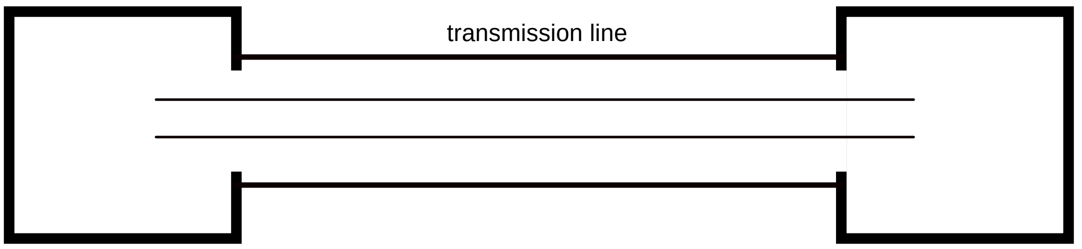
1.5 ILLUSTRATIONS

Figure 1 : The overall simplified SPIRE instrumentation chain
It shall be noted that the term of « grounding » is a bit improper since only reference to local enclosure voltages can be used in that chain.

Figure 2: EMC parameters to be computed and consolidated for the best performances.



EMC SPIRE GENERAL CONSIDERATION



2 main parasitic mechanisms:

—Induced voltage in signal bandwidth (electromagnetic field in loop, current injection in common impedance, cross effect...)

—RF detection in unlinear devices

Common mode induced voltage is more problematic for space application

global CMR(f) = VDM/VCM = CMRdev(f) * TI(f) * X(f) * ACM(f)

CMRdev	:	Common mode rejection of victim device
TI	:	Transfer impedance (cable shielding efficiency)
X	:	unbalanced line impedance/coupling factor
ACM	:	Common mode filtering attenuation factor